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ECONOMIC PERSPECTIVES ON REGIONAL ENERGY DEVELOPMENT ISSUES

November 1984

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ECONOMIC PERSPECTIVES ON REGIONAL ENERGY DEVELOPMENT ISSUES

by

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FINAL REPORT

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INTRODUCTION

The U.S. Office of Technology Assessment is conducting a study of potential technological responses to a large and permanent oil price rise due to a disruption in oil imports of three to four million barrels per day. The major objectives of the study are to ascertain how much oil can be displaced and how quickly in such a crisis, and to estimate what ameliorating effects the oil displacement might have on the economic impacts of the oil price rise.

One of the issues related to this assessment is the relationship between regional and national impacts of various oil displacement options. Clearly, regions of the country will be affected differently by the selection of oil displacement technologies just as they are differentially impacted by oil price increases. For example, adoption of enhanced oil recovery clearly would have different regional (and probably national) impacts from adoption of grain alcohol production. The major objective of this "issue analysis" is to delineate and clarify some of the major issues, tradeoffs, and value judgements associated with the analysis of regional impacts of oil displacement options. Three important sub-objectives are the following:

1) Explain the major economic principles relevant to this analysis,

2) Review some of the studies that have been done of employment and earnings impacts of alternative energy development strategies, and

3) Present case studies of regional development of renewable energy technologies.

Before proceeding with these objectives, it may be useful to provide some background information related to this topic. Discussions on alternative energy strategies intensified significantly with the publication of Armory Lovins *Foreign Affairs* article and his subsequent book [Lovins, 1976, 1977]. In these and other publications, Lovins argued for a "Soft Energy Path." While I cannot completely describe the soft path here, its main characteristics include use of more decentralized energy sources, attempting to get a better (more efficient) match between energy source and end use, avoidance of centralized electricity (especially nuclear power), and more local control over energy production and use. Publication of the soft path materials and the subsequent national attention they received generated numerous challanges and critiques [Nash]. In some quarters, an emphasis on renewable energy resources and on regional development through energy policy became identified with

the soft path advocates, even though Lovins notion of the soft path encompassed much more than that. Even today, discussions of local energy development initiatives often center around renewable energy resources such as converting grains or other raw materials into alcohol. In this paper we will use renewable energy resources as case studies and generally will link the regional development discussion to regional development through the use of locally available renewable energy resources. It should be understood, however, that regional development is affected by changes in availability and price of any energy resource and that each region is affected differently [Lakshmanan].

Following this introduction, the paper is organized into three major sections. Section II provides a discussion of the major economic issues associated with this analysis. It is divided into three major parts, the first of which provides an overview of the relationship between national economic policy and the extent to which any of the oil displacement options will be developed. The next part provides a brief explanation of some of the basic economic principles which will be used or referred to in this analysis. The last part discusses the concepts and techniques used in regional economic analysis that are directly relevant to this paper. Included in that part is a review of some of the previous work which has been done on the employment and income impacts of development of solar and other renewable energy technologies. Section III presents the three case studies: (1) Alcohol from cheese whey in New York, (2) Grain alcohol in the Mid-west, and (3) Wood energy in New England. The emphasis in reporting on each of the case studies is regional employment and earnings impacts associated with the technology. The final section draws upon the previous sections to summarize what we can say in general from an economic perspective about regional and national development implications of alternative oil displacement strategies.

MAJOR ECONOMIC ISSUES

National Policy Perspective

Clearly the national policies in effect at the time of and immediately after an oil supply disruption would have an important bearing on the development of the various oil displacement technologies. We cannot here provide a comprehensive review of all the possible policy alternatives and their differential effects, but it is to useful summarize some of the general categories of policies that might be used. In the 1970s the U.S. used a combination of price controls on domestic oil and entitlements to allocate the price controlled domestic supplies among the petroleum refiners. Because domestic oil prices were held down, development of oil import displacement options was not encouraged through market signals. U.S. energy policy during the 1970s has been widely criticized by economists [see Mitchell] because of the inefficiencies introduced by the system of controls and regulations. Clearly, if a similar policy environment were to be created following a future disruption, development of any of the oil alternatives would be affected.

Energy policy objectives

Energy policy, like policy in any other area, is formed in a multi-objective framework; that is, government is trying to accomplish to different degrees several (sometimes conflicting) goals simultaneously. Two of the most important objectives are fairness and efficiency, or what economists like to call efficiency and equity. The driving force behind the price controls implemented following the 1973 oil embargo was the attempt to protect American comsumers from high energy prices and at the same time to prevent receipt of windfall profits by the oil companies. Clearly, the price control policy was implemented to achieve the fairness objective. Similarly with the entitlements program, the major objective was to fairly distribute to price controlled domestic oil.

To the extent that it is percieved in Congress and other policy making institutions that fairness somehow requires consumer protection from high energy prices, attainment of the fairness objective conflicts with achievement of economic efficiency. In this case, keeping oil prices artifically low following a disruption in supplies would prevent the sending of market signals to consumers to curtail oil consumption and to producers of oil import displacement options to increase productive capacity. Hence, any of the technical oil displacement options covered in this study will require a favorable policy environment for rapid implementation.

Policy alternatives

What policy alternatives exist at the national level to

handle a future oil supply disruption? The list of possibilities is endless, but we can summarize some of the important general types of policies. We will cover the following policy sets:

1)Price controls plus rationing
2)Price controls and rationing plus subsidies for oil alternatives
3)Market determined pricing with no government intervention
4)Market pricing with a windfall profits tax on domestic production
5)Market pricing with a windfall profits tax plus an energy subsidy program for low income consumers

The general effects of each of these policy sets will be described briefly. The first set consisting of price controls and rationing is essentially the type of policy followed by the U.S. in the 1970s. Because economic incentives are not conveyed to producers, development of oil displacement options is not encouraged and likely would proceed quite slowly.

The second policy set, which consists of price controls and rationing plus subsidies for oil alternatives, also was followed to some extent in the 1970s. Subsidies were provided for alcohol, synthetic fuels, and for solar energy. The subsidies are necessary given price controls to permit any production of the oil alternatives. The equity effects of this policy set relative to a market approach are to transfer income from domestic oil producers to oil consumers and to transfer income from taxpayers to producers of the subsidized oil alternatives and to energy consumers. The major efficiency effects are "too much" energy consumption and the shift in investments from the relatively lower cost domestic oil to the relatively higher cost oil alternatives.

Policy set three is the pure market approach. Higher oil prices due to the supply disruption are immediately passed on to oil consumers. Consumption is reduced reflecting the higher prices, and rapid development of alternatives is encouraged so long as the higher prices are perceived to be permanent. The sharp increase in energy prices will cause a reduction in the rate of economic growth [Hudson and Jorgenson], perhaps sending the country into an economic recession. However, after a period of adjustment, the economy can resume growing again.

The fourth policy set is market pricing plus a windfall profits tax on domestic oil production. The effects of this alternative would be similar to policy set three except that the windfall received by domestic oil producers would be taxed. Conceptually at least, it is possible to design a windfall profits tax that would not change economic efficiency. So the decision on whether or not to institute a windfall profits tax is largely a matter of equity or fairness. Is it "fair" that the oil companies receive the increased profits from unanticipated oil price increases?

The last policy set to be discussed here consists of market pricing, a windfall profits tax, and an energy subsidy for low income consumers. The energy subsidy component could be something like energy stamps patterned after the food stamp program. Low income consumers would receive energy certificates which could be used to pay a portion of their gasoline and other energy purchases. All or part of these energy subsidies could be financed with revenues from the windfall profits tax. This policy set has the advantage that the higher oil prices are transmitted to energy consumers and producers, but the windfall profits tax and energy subsidy program help to achieve the equity objective as well.

Policy planning

Whatever policy set is preferred, it is important to consider and decide on a policy set in advance of an oil supply disruption. This author believes that Congress should consider oil disruption policy legislation now so that 1)the alternative policy sets can be evaluated in a more reasoned manner apart from the "emotion of the moment" when a disruption actually occurs, and 2)the administrative structure and any necessary regulations to implement the chosen policy set can be prepared.

Some Basic Economics

The purpose of this section is to present some basic economic principles related to international trade and regional development. One may legitimately question why this is necessary in a paper of this type. Why not simply reference a standard text? The reason is that some of the trade principles of absolute and comparative advantage are very poorly understood, yet they are at the heart of any analysis of international trade or regional economic development. Readers with a good understanding of these principles may safely proceed to the next section on regional development analysis (page 7).

Why the concern with international trade economics in a paper on regional development issues? The answer to that question is that regional development in some ways is a simplifed case of national development in an open economy with international trade. It is a simplified case because we don't have to worry with the exchange rate and because trade barriers such as tarriffs and quotas don't exist. Hence, we can learn from the economics of international trade some principles which will be useful for regional development analysis.

Absolute and comparative advantage

The principles of absolute and comparative advantage go back to the early classical economists [Smith, Ricardo]. This section draws upon their work as well as others [Adams, Samuelson] to explain these principles. Adam Smith originally established the principle of absolute advantage which states that two countries can both benefit from trade when each country can produce

something cheaper than the other. For example, if Portugal can produce wine cheaper than England and England can produce cloth cheaper than Portugal, then both countries can be better off with the exchange of wine from Portugal for cloth from England. Portugal has an absolute advantage in producing wine and England an absolute advantage in producing cloth.

Ricardo went beyond the principle of absolute advantage to demonstrate that both countries could benefit from trade even if one country had an absolute advantage in production of both commodities. That is, even if costs of production for both goods were lower in one of the two countries, both countries could still benefit from trade. This seemingly implausable result perhaps is most easily understood by means of illustrations. The following example is taken from Samuelson:

A traditional example used to illustrate this paradox of comparative advantage is the case of the best lawyer in town who is also the best typist in town. Will she not specialize in law and leave typing to a secretary? How can she afford to give up precious time from the legal field, where her comparative advantage is very great, to perform typing activities in which she is efficient but in which she lacks a comparative advantage? Or look at it from the secretary's point of view. She is less efficient than the lawyer in both activities, but her relative disadvantage compared with the lawyer's is least in typing. Relatively speaking, the secretary has a comparative advantage in typing.

The same principle holds with countries or regions within a country. Lets return to the wine and cloth example with Portugal and England. Suppose that the costs in the two countries (in man-hours per unit of output) are as follows:

	Cloth	Wine
Portugal	90	80
England	100	120

The cost of both wine and cloth is lower in Portugal. However, Portugal has a comparative cost advantage in wine production. The cost of producing cloth in Portugal is 90 percent of the cost in England, but the cost of producing wine is only 67 percent of that in England. Under these conditions, both countries can gain from trade. England can trade one unit of cloth costing 100 units of labor for one unit of wine costing Portugal 80 units of labor. The wine would have cost England 120 units of labor, so England is better off by 20 units of labor. Correspondingly, without trade it would have cost Portugal 90 units of labor to produce the cloth, so Portugal is better off by 10 units.

Another way to illustrate the gains from trade is through the use of production and consumption possibility curves, which show all the combinations of goods that are possible given the country's resources and level of technology. Production possibility curves for Portugal and England (without trade) are

the interior lines on the graphs illustrated in Figure 1. The interior line shows the production and consumption possibilities without trade and the top line, the consumption possibilities with trade. Clearly the availability of goods is increased in both countries with trade. With more goods being available for the same labor input, real wages have increased, and the people in both countries are better off.

It has been argued that comparative advantage is not relevant when the good under consideration is a final consumer good (such as household energy consumption) [Krass, et. al.]. The above example with wine and cheese as the traded goods clearly demonstrates that this argument is incorrect. The principle of comparative advantage holds whether the goods are final consumer products or intermediate goods used in production.

Comparative advantage and regional development

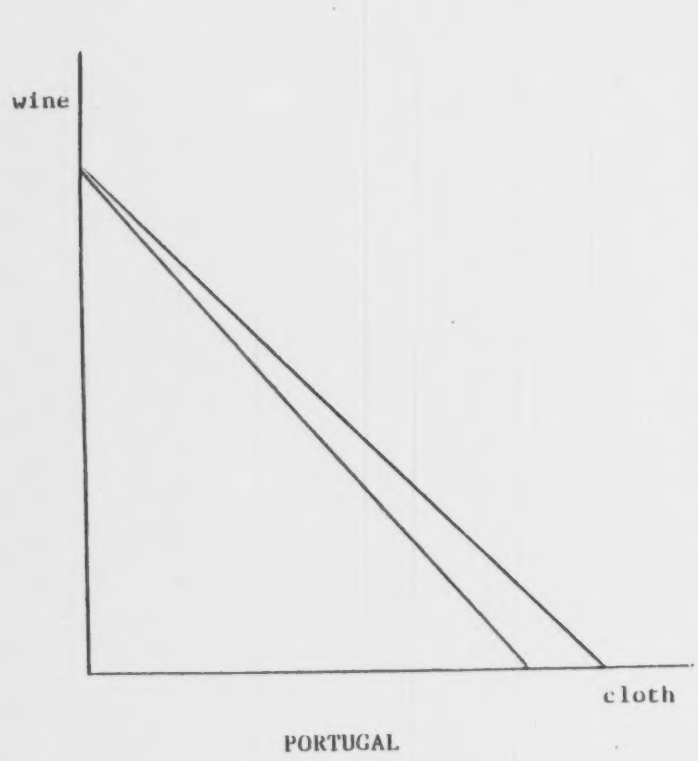
The same line of argument holds for trade between regions as for trade between countries. Regions develop and grow by specializing in producing those products for which they have a comparative advantage. This is illustrated by the conclusion to a study on energy and regional growth [Lakshmanan]:

Given the greater concentration of economic activity in the North and East, and of energy resources in the South and West, it is to be expected that rising energy prices will favor the terms of trade of the energy-producing regions. However, the argument that the older industrial regions (such as New England or the Middle Atlantic seaboard states) will consequently suffer serious economic hardships is overstated. The energy-importing states appear to have adjusted historically to higher energy prices: (1) "structurally" (by specializing in producing a lower proportion of energy-intensive goods and services than the energy-exporting states) and (2) by lower energy intensity, producing a given activity mix with less energy. Furthermore, an older energy-importing industrial region like New England is increasingly specializing in high valued goods and services that have a high income "elasticity" of demand (e.g., educational, medical, and high-technology services), leading the transition of the United States into a postindustrial services-oriented economy. Such developments reduce the region's relative vulnerability to higher energy prices.

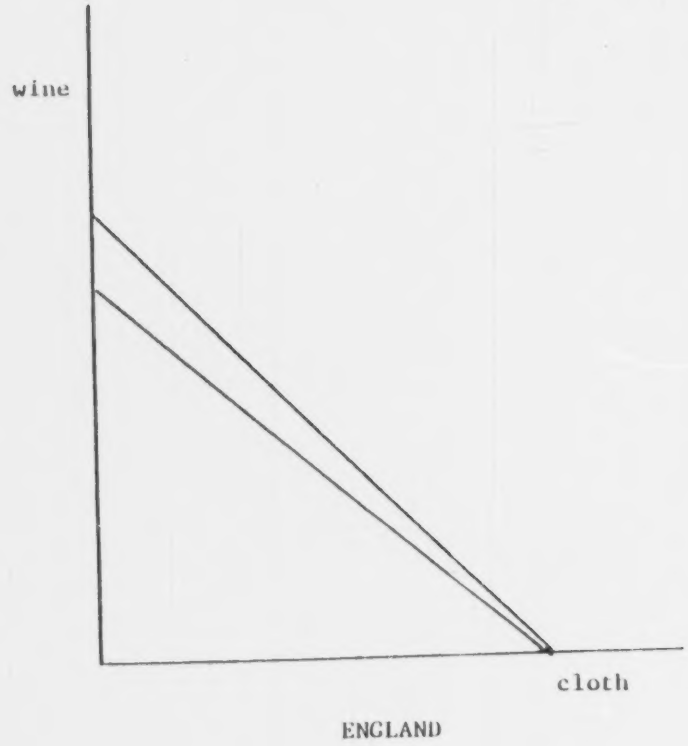
Hence, just as Japan has grown by specialization and trade (importing virtually all its energy), regions within the U.S. appear to be doing the same thing.

Regional Development Analysis

Regional economics has been defined as ". . . the way in which economic activities are distributed geographically within an economy and the economic results of that distribution." [Sadler, et. al.] In recent years, quite a bit of work has been



PORTUGAL



ENGLAND

FIGURE 1

COMPARATIVE ADVANTAGE AND CONSUMPTION POSSIBILITIES

reviewing some of that work, it will be useful to provide an overview of the effects on income and employment from energy development, and to discuss some of the techniques that are used to estimate the magnitude of these effects.

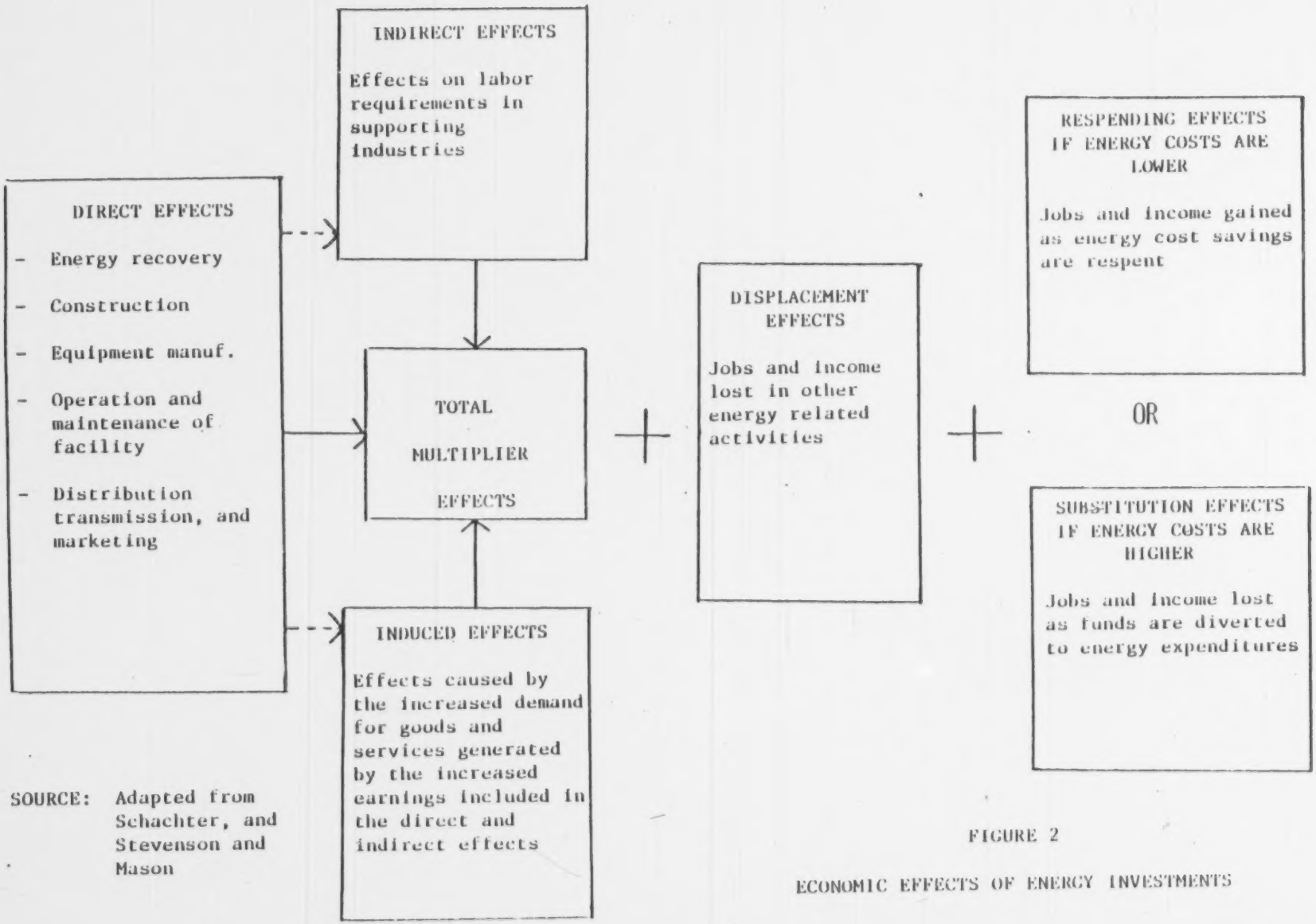
Regional effects of energy development

Figure 2 summarizes the employment and income effects of investment in an energy technology. The total effects are divided into several components which will be defined and discussed briefly [Schachter, Stevenson and Mason]. The direct effects of an energy development are the jobs and income created in the construction and operation of the energy facility. Indirect effects are the earnings and employment created in supporting industries linked to the energy development. In adddition to the direct and indirect effects, employment and earnings may also created in other industries because of the increased demand for goods and services generated by the employment and earnings included in the direct and indirect effects. This increase in employment and income is termed the induced effect. Induced and indirect effects are often combined and termed secondary effects. The multiplier effect is the total of the three effects and estimates the impact of a change in spending in one part of the economy on economic activity in the region.

Investment in a new energy alternative, say alcohol fuels, is likely to reduce labor requirements in another energy industry. This reduction is called the displacement effect. If the cost of the alternative energy source is different from the conventional source being displaced, an additional respending or substitution effect must be considered. If the cost of the new energy source is lower, the respending effects will result in job creation as the energy cost savings are respent in other sectors of the economy. If the cost of the new energy source is higher, jobs and income will be lost as funds are diverted from other spending to energy expenditures.

In addition to these five effects, the net earnings and employment effect can also depend on the financing effect. Assuming there are no idle investment funds with no other use, investing in an energy facility will divert funds away from other productive uses. For the case of investments financed or subsidized with taxes, the taxes collected for that purpose divert funds away from consumption and other private investment. For investments financed or subsidized through public sector borrowing, the interaction is through capital markets. Public borrowing to some extent displaces (or crowds out) private borrowing by increasing the interest rate in the nation's capital markets (everything else being equal).

Clearly, the complete analysis of the regional or national impacts of investments in alternative energy sources is not simple. In fact, to include all the effects described above and depicted in Figure 2, one would need what is called a computable


INDIRECT EFFECTS
Effects on labor requirements in supporting industries
DIRECT EFFECTS
- Energy recovery
- Construction
- Equipment manuf.
- Operation and maintenance of facility
- Distribution transmission, and marketing
TOTAL MULTIPLIER EFFECTS
INDUCED EFFECTS
Effects caused by the increased demand for goods and services generated by the increased earnings included in the direct and indirect effects
DISPLACEMENT EFFECTS
Jobs and income lost in other energy related activities
RESPENDING EFFECTS IF ENERGY COSTS ARE LOWER
Jobs and income gained as energy cost savings are respent
OR
SUBSTITUTION EFFECTS IF ENERGY COSTS ARE HIGHER
Jobs and income lost as funds are diverted to energy expenditures

SOURCE: Adapted from Schachter, and Stevenson and Mason

FIGURE 2

ECONOMIC EFFECTS OF ENERGY INVESTMENTS

general equilibrium model. Such a model or group of models includes all the micro and macro-economic effects described above. However, these models are difficult and expensive to build and use, and most analysis stops far short of considering all the effects described above. In fact, most of the work that has been done to date has considered only the direct effects of investment in energy alternatives. We will review some of the previous work below, but first we need to describe some of the techniques used in this type of analysis.

Methods for regional analysis

Employment and earnings impacts of energy investments can be evaluated using combinations of at least five different methodologies: economic base analysis, demographic-economic interaction models, shift-share analysis, industrial location analysis, and input-output (I-O) analysis [Ferris, Mason]. By far the most common technique used in the studies done to date on renewable energy investments is input-output analysis. In this section we will briefly describe input-output analysis, present some of its limitations, and review some of the studies that have been done using I-O techniques.

Input-output analysis

Space does not permit a complete description of input-output analysis, but we can provide a brief summary that will be useful in the subsequent discussion. This discussion draws heavily upon Ferris and Mason, Samuelson, and Bendavid. Input-output differs from other types of income and GNP accounting in that it deals with interindustry transactions which are behind the GNP and national income accounts. An input-output model consists of three principle tables. The first is the transactions table which contains dollar flows from producing sectors to consuming sectors for both intermediate and final demands. Each industry appears in both a row and a column. The row for each industry shows the distribution of its output as inputs to other industries and for final demand. The column for each industry contains the inputs from all industries needed to produce that industry's output. Figure 3 represents a simple transactions table assuming there are no imports or exports, no government, no savings or investment, and no inventory. Households constitute the only final purchaser and the only primary inputs supplier. Though extremely simple, this table is adequate for our present purposes. The right hand column and bottom row show total or gross output including the amounts needed as intermediate inputs. National product and income are the sums of the final use column(s) or primary suppliers row(s). Figure 4 shows a more generalized transactions table.

The transactions table can be transformed into a technical coefficients table which is more useful for analytical purposes. This table is computed by dividing the value of total production of each sector (the column sum) into each of the column elements. Hence, each coefficient represents the proportion of total cost

Goods Sold by / Goods Purchased by		Intermediate Uses		Final Uses	Total Output
		Agriculture	Manufacturing	Households	
Processing Suppliers	Agriculture	10	30	60	100
	Manufacturing	5	10	35	50
Primary Suppliers	Households	85	10	15	110
Total inputs		100	50	110	260

FIGURE 3

A SIMPLE INPUT-OUTPUT TRANSACTIONS TABLE
(Thousands of Monetary Units)

SOURCE: Bendavid

				PURCHASING SECTORS: Intermediate Demand — Agriculture; Mining; Manufacturing; Trade; Services; Finance	PURCHASING SECTORS: Final Demand — Household consumption; Govt. expenditures; Gross domestic capital formation; Exports	Total gross output
				Quadrant I intermediate production & consumption	Quadrant II final outputs of producing sectors	
Producing Sectors	Intermediate Inputs	Agriculture	1	$a_{11} \cdots a_{ij} \cdots a_{1n}$	C_1 G_1 I_i E_1	X_1
		Mining	.	.	. . . .	.
		Manufacturing	.	.	. . . .	.
		Trade	i	$a_{i1} \cdots a_{ij} \cdots a_{in}$	C_i G_i I_i E_i	X_i
		Services	.	.	. . . .	.
		Finance	n	$a_{n1} \cdots a_{nj} \cdots a_{nn}$	C_n G_n I_n E_n	X_n
				Quadrant III primary inputs to production	Quadrant IV primary inputs to final demand	
	Primary Inputs	Payments to:				
		Households		$H_1 \cdots H_j \cdots H_n$	H_C H_G H_I H_E	H
		Government		$T_1 \cdots T_j \cdots T_n$	T_C T_G T_I T_E	T
		Depreciation		$D_1 \cdots D_j \cdots T_n$	D_C D_G D_I D_E	D
		Imports		$M_1 \cdots M_j \cdots M_n$	M_C M_G M_I M_E	M
TOTAL GROSS OUTLAYS				$X_1 \cdots X_j \cdots X_n$	C G I E	X

FIGURE 4

GENERALIZED TRANSACTIONS TABLE

SOURCE: Ferris and Mason

of product j that is accounted for by the cost of input i. In symbolic terms, the technical coefficient, $a_{i,j}$ is equal to $x_{i,j}/x_j$ where:

x = an element of the transactions table expressed in $
i = row
j = column
a = technical coefficient

The technical coefficient table thus represents the linkages among industries for any regional or national economy. Figure 5 is the technical coefficients table derived from Figure 3.

To estimate the multiplier effects of exogeneous changes in an economy, we convert the technical coefficients table into a table of direct and indirect coefficients. To understand the process of calculating I-O multipliers, we need to look again at Figure 4. The columns (purchasing sectors) are divided into intermediate and final demand. The rows (producing sectors) are divided into intermediate and primary input sectors. Multiplier calculation begins with a change in one or more of the components of final demand. The multiplier is calculated by multiplying the change in final demand by the matrix of direct and indirect coefficients. Derivation of this matrix is explained below [Ferris, Mason].

Any row from Figure 4 can be expressed as follows:

$$X_i = \sum_{j=1}^{n} a_{i,j} X_j + \sum_{j=1}^{n} Y_{i,j}$$

Using matrix notation, the complete system can be written as follows:

$$X = AX + Y \qquad \text{where,}$$

X = vector of total outputs
A = technical coefficients matrix
Y = vector of final demand

With matrix algebra, we can now express the vector of total outputs, X, as a function of the vector of final demand, Y:

$$X = (I - A)^{-1} Y$$

This equation is the basis for the calculation of output, employment, and income multipliers. The $(I-A)^{-1}$ matrix is the matrix of direct and indirect coefficients. The output multiplier from a unit change in final demand is the sum of the impacted industry's column from the $(I-A)^{-1}$ matrix. Employment multipliers are normally calculated in one of two ways. First the $(I-A)^{-1}$ matrix can be multiplied by an exogeneous diagonal matrix of labor coefficients. Alternatively, the multiplier can be calculated by multiplying total output change by the ratio of

Requires / Output	Agriculture	Manufacturing
Agriculture	0.10	0.60
Manufacturing	0.05	0.20
Households	0.85	0.20
Total direct inputs	1.00	1.00

FIGURE 5

A SIMPLE INPUT-OUTPUT DIRECT
REQUIREMENTS TABLE
(Direct Requirements Coefficients: Direct
Requirements per Unit of Final Delivery)

SOURCE: Bendavid

employees per dollar of output. There are two types of income multipliers commonly used. Calculation of these multipliers proceeds in a similar manner, but is a bit more complicated and will not be covered here.

From this description of input-output analysis, it should be clear that it offers considerable insight into the structure of an economy or region and the interactions among the various economic sectors. It is important, however, that we understand the assumptions underlying input-output analysis and the limitations these assumptions may place on its use [Fechtel and Novicky]. First of all, input-output analysis is static; it represents a snapshot of an economy at a particular point in time. The technical coefficients derived from this snapshot are fixed; hence, price changes do not induce technical changes. The economic forces of supply and demand do not interact to determine price and quantity changes. An exogeneous increase in demand is produced with increased amounts of production factors paid at the same price as the previous quantities. Therefore, quantity balances are maintained. It is in the Keynesian tradition of demand creating supply, which is likely to be accurate only if there are unemployed resources in the economy.

This problem can be seen most clearly when input-output analysis is used to predict changes in employment from rather large changes in total output, such as was done in the large solar penetration cases of the *Domestic Policy Review of Solar Energy*. If resources are fully employed before implementing a new policy, there may be a change in the composition but not the level of resource utilization. Input-output analysis, however, would indicate a change in employment because it does not consider these supply and demand issues. Again, the I-O results are appropriate only if the assumption of unemployed resources is valid.

Another problem with I-O analysis is that it assumes average rather than marginal relationships. To the extent that industries are characterized by economies of scale, average technical coefficients would tend to overstate the employment and other effects.

Another problem that has been mentioned with respect to I-O analysis is in the aggregation of industries. This mainly becomes an issue when it is desirable to disaggregate an industry and add another industry row and column for some special analysis (such as empolyment effects of solar energy). Not only must the coefficients for the new industry be determined but the coefficients for existing sectors must be adjusted appropriately.

Still, input-output analysis continues to be the most widely used tool for determining employment impacts of exogeneous demand or policy changes. The next section reviews some of the studies what have been done on employment impacts of renewable energy sources.

Employment impact studies

In the late 1970s there was considerable interest in the employment impacts of alternative energy strategies. Quite a few studies were done which examined employment of solar or renewable energy strategies [*Domestic Policy Review*, Dossani and Preziosi, Earley, Little and Stevenson, Marcuse and Groncki, Petersen, Rodberg, Schachter, Stevenson, and others]. In addition to these national studies, several other studies were done that took a local or regional orientation. The regional studies will be discussed with the regional case studies in the next section.

Most of the studies that were done looked only at direct or perhaps direct plus indirect employment impacts [Stevenson and Mason, Schachter]. Stevenson and Mason provide an excellent review of the work that has been done, and Fechtel and Novicky provide a good evaluation of several of the major studies using input-output analysis.

After examining several of the studies that estimated direct employment impacts of increased use of solar energy, Schachter concluded that residential solar applications can generate two to eight times more jobs than conventional alternatives. She also concluded that direct job creation for centralized solar is not very different from other options. Energy conservation appeared to create fewer jobs than many other options.

A study by Dossain and Preziosi compared direct plus indirect employment of seventeen energy technologies including three solar technologies. Direct plus indirect job creation in the three solar technologies was substantially greater than in any of the other energy technologies.

Another study by Petersen estimated direct and indirect employment changes from a large-scale solar heating and hot water industry. He concluded that the employment changes would be relatively small and that only four sectors would experience changes as large as 1 percent of the baseline work force in that sector.

Rodberg conducted a study of employment impacts of increased solar energy for the Joint Economic Committee of Congress. The program assessed by Rodberg would require investments of $500 billion in the 1980s, provide a savings of 45 quads (or $119 billion) of nonrenewable energy in 1990, lead to an increase in disposable income of $53 billion, and lead to creation of 2.9 million jobs in 1990. The analysis assumes an autonomous increase in spending of $66 billion (1978$), but provides no explanation of how this would occur [Fechtel and Novicky]. Rodberg estimates that the conservation and solar programs would lead to a gross output decline of electricity of $84 billion, or by 77 percent of the electricity base output. He assumes that electric utility investment would decline $16 billion annually and investment in new technologies such as photovoltaics would

increase $12 billion annually. The investment increase seems unreasonable if less than 40 percent of the existing 1980 electricity capacity is being utilized. In addition to these problems, there are quite a few others raised by Fechtel and Novicky.

Economic impacts of ethanol production

A 1981 study done for the Department of Energy by Resources Planning Associates did an analysis of the impacts of ethanol production in the forty eight states (excluding Alaska and Hawaii). The study estimated changes in the level of economic activity and federal and state tax collections due to production and sale of ethanol from a 50 million gallon plant in each state.

The study concluded that "... substantial direct economic benefits accrue to all states in producing and using ethanol as a motor fuel." [Resource Planning Associates, pp. i-ii] State tax receipts fell in states with a gasohol tax exemption of three cents or more per gallon and increased in the others. Federal tax receipts increased in all but four states even with the four cent gasohol tax exemption.

If these results seem to good to be true, they are except under a very special set of curcumstances. The results assume that there are no alternative uses for the resources in the absence of ethanol production. In other words, without the alcohol plant, the corn would not be grown, the farmer would be unemployed, the land would lie idle, the fertilizer would not be produced and on and on. Similarly, investment funds available for building an ethanol plant would have no other use that also would generate jobs, income, and taxes. Indeed, if other investment opportunities were available and profitable without subsidy, the state and federal coffers would be better off because the subsidies would not be needed to reap the income, employment, and tax gains. For example, suppose that an alternative use of funds would be to build and operate a hog operation. Suppose furthur that the hog operation were sized to use the same amount of corn as the ethanol plant. The hog operation would then generate the same stream of jobs, income, and taxes in the corn production sector. It would also generate jobs, income, and tax receipts in converting the corn and other inputs into pork. Since the hog operation is profitable (by assumption), it would no doubt generate higher net tax income than the ethanol plant, which requires substantial state and federal tax subsidies to be profitable.

The main point is that any investment can be made to appear desirable using these employment and income impact estimation techniques. The real question is whether or not these benefits are greater than or less than the costs. The costs include alternative investment opportunities that are foregone by a public policy decision to direct (or subsidize) investment into any particular industry. This topic is explored furthur in the next section on macroeconomic studies.

Macroeconomic studies

A few studies have been done using macroeconomic models linked with input-output models. One study by Earley used the DRI macroeconomic model together with an energy disaggregated input-output model. That study assumed that solar energy could be cost competetive with the oil fired electricity it displaced. The study concluded that under this assumption the solar energy program would have slightly positive effects on the economy [Stevenson and Mason]. By 1985 real GNP increases 0.1 percent and unemployment declines by less than 0.1 percent. The price level increases about 0.2 percent above the base case by 1985.

Another macroeconomic study was done by Marcuse and Groncki using the Hudson-Jorgenson macroeconomic model, the Brookhaven National lab energy process model, and the University of Illinois input-output model. This study concluded that when solar energy is cost competitive, achieving a 15 quad penetration level by 2000 would not have any significant impact on employment, productivity, or economic growth. In addition to the equal cost case, this study also included two other cases for which solar technologies were more expensive than conventional technologies. In one of these it was assumed that the cost difference was made up through government provided subsidies, and in the other that consumers were made to pay the higher cost. The authors' conclusion to the subsidy case is as follows [Marcuse and Groncki, p. 12]:

Both the absolute level of GNP and the growth rate are lower in the subsidy case than in the base case because the solar technologies are less efficient per dollar cost in providing energy than the lower cost conventional alternatives. The required labor and capital inputs per unit of energy output are increased and this reduction in productivity is reflected throughout the economy in the form of lower wages, decreased return to capital, and a fall in output.

For the consumer pays case, the authors conclude:

Like the subsidy case, both GNP and its growth rate decrease relative to the base case, because there is no supplement to offset the higher energy costs, the absolute level and the growth rate of GNP are smaller than in the subsidy case. Most of the decrease occurs in consumption since the additional expenditure for energy must come largely from consumer expenditures.

Although the negative changes in GNP growth were small in both cases, these results do illustrate the importance of including all the economic effects rather than just the direct or direct and indirect employment impacts.

From all these studies we can draw some general conclusions. First, there is little doubt that the direct and indirect employment effects of investment in renewable energy sources is

positive resulting in substantial job creation. Second, when the rest of the economic effects are considered as well in a macroeconomic framework, the total net changes in employment and income appear to be quite small. Jobs are still created in the solar and related industries, but jobs are lost in other sectors. Third, the macroeconomic impact of investments in renewable energy depend mainly of the relative cost of the technologies. If renewable energy technologies are generally less expensive than conventional technologies, the macroeconomic effect will be to stimulate growth and create jobs. On the other hand, to the extent that the renewable energy technologies are more expensive than the technologies they displace, the effect on the economy is likely to be negative, despite the fact that jobs will be created in those industries.

REGIONAL CASE STUDIES

This section contains three regional case studies of renewable energy investments. The first is of cheese whey alcohol plants in New York state, the second is grain based alcohol located in the Midwest, and the third is a wood fired power plant in New England.

Cheese Whey Ethanol Conversion in New York State

This section reviews the economics and regional impacts of investments in facilities to convert cheese whey to ethanol in New York state. It is based on an excellent series of studies done by Kalter et al. of Cornell University.

Technology description

Cheese whey is a by-product (sometimes a waste product) of making cheese, which contains the sugar lactose that can be fermented directly into ethanol. This study assumes that the cheese whey is deproteinized and condensed to 40 percent solids prior to shipping to the alcohol facility. Kalter et al. developed four different plant designs ranging from a 1.675 million gallon per year cheese whey only plant to a 27.5 million whey and corn grain plant. Production of alcohol from deproteinized whey also yields a high mineral-medium protein by-product suitable as a feed product for dairy cows.

Economics

The Kalter et al. study examined the impacts of alcohol production in five different locations in New York state. For the sake of convenience, we will concentrate our reporting on the Southwestern New York region and on the summary volume covering regional impacts. The Southwestern region of New York produces about 1.2 billion pounds of cheese whey annually, which limits annual alcohol production capacity to one 2.5 mil. gal./yr. plant. Cheese production in all the New York regions studied limits alcohol production from whey to three plants of this size.

The analysis of commercial potential for the alcohol plants was done using a Monte Carlo discounted cash flow model [Tyner, et al.]. The major assumptions used for the economic analysis are given in Table 1. Table 2 provides the break-even costs of producing ethanol for each of the four plants. These costs exclude the 40 cent per gallon federal subsidy, so the pure economic cost of alcohol would be 40 cents higher than these levels.

The results generally indicated that with the alcohol prices expected to increase at 4 percent real per year, the alcohol from cheese whey plants were economical. The corn or corn/whey plants generally were marginally economic given the underlying

TABLE 1

PRINCIPLE ECONOMIC, INSTITUTIONAL AND POLICY ASSUMPTIONS FOR "REFERENCE CASE" DCF ANALYSES

Item	Value
Cost Related Inputs	
Investment cost contingency distribution	
Minimum	+5 percent
Maximum	+20 percent
Most likely	+10 percent
Operating cost contingency distribution	
Minimum	-10 percent
Maximum	+10 percent
Most likely	0 percent
Operating cost annual real rate of change	1 percent
Working capital factor	10 percent of annual operating costs
Planning Horizon	
Length of plant construction period	2 years
Length of plant production	20 years
Economic and Tax Values	
Discount rate (real rate of return)	10 percent
Loan Interest Rate (Nominal)	14 percent
Debt-Equity ratio	50/50
Depreciation	
Method	Sum of Years Digits
Lifetime	10 years
Salvageable Investment	5 percent
Rate of Inflation	10 percent
Federal tax credits	
Investment Tax Credit	10 percent
Energy Investment Credit	10 percent

Table 1 Continued

Item	Value
Tax Rates	
Federal	46 percent
State	4 percent
Price of Ethanol	
Base price (initial year of analysis)	$1.30/gallon
Annual rate of increase (normally distributed)	
Mean rate	4 percent
Standard deviation	1 percent
Price subsidy:	$.40 nominal tax credit through 1992
Price of By-Product	
Batch whey by-product	$140/ton
Continuous whey by-product	$90/ton
Corn/whey by-product	$130/ton

SOURCE: This table was taken from Kalter, et al., Ethanol Production in Southwestern New York.

TABLE 2

MARKET PRICE OF ETHANOL REQUIRED FOR PLANT ECONOMIC FEASIBILITY[a]

Plant Design	Price per Gallon Ethanol
2.5 mm Gallon Ethanol Conversion Plant (Whey)	0.89
1.675 mm Gallon Ethanol Conversion Plant (Whey)	1.14
27.5 mm Gallon Ethanol Single Line Conversion Plant (Corn/Whey)	1.42
27.5 mm Gallon Ethanol Parallel Lines Conversion Plant (Corn/Whey)	1.46

[a]These values are derived assuming the nominal $0.40 per gallon federal tax credit and should be interpreted as the required constant wholesale price, over 20 years of production, necessary to obtain a 10 percent real rate of return on equity.

SOURCE: This table was taken from Kalter, et al., Ethanol Production in Southwestern New York.

assumptions. The assumption of 4 percent real alcohol price increase is particularly important to the economic conclusions. With that assumption the real alcohol price rises from an initial $1.30 to $3.13 at the end of the plant life.

Production timing

Alcohol plants can be built in two years. If we limit ourselves to cheese whey plants, only three plants would be needed to exhaust the whey supply in New York state. Since these plants would be in different parts of the state, there appears to be no reason why the plants could not all be completed in two years if economic conditions warrant.

Regional impacts

Kalter et al. used regional input-output models to estimate economic and employment impacts of different alcohol plants in several New York locations. Tables 3 and 4 summarize the construction and operation direct and indirect impacts of the 2.5 mil. gal./yr. whey plant and the 27.5 mil. gal./yr. whey/corn plant. The impacts of the larger plant were higher than the smaller plant, but the impact per unit of capacity was much higher for the smaller plants. This result was obtained because the corn for the large plants had to be imported. The gross value added multipliers (total change in value added divided by the direct change) averaged 1.7, which is small relative to that reported in other studies. One reason for this is that the regions where the plants were located were relatively small, and hence had to import much of the equipment.

Even with the wealth of information like that reported in Tables 3 and 4, the policy maker is still left with the question of what if any policy changes to implement. Kalter et al. summarize this dilemma as follows:

To the authors' knowledge, there is no objective basis on which to tell how large these regional impacts should be before public policy is justified. Such decisions must be made at the local level and depend on the complexity of the development, the uncertainty surrounding it, the availability of public resources and alternate uses of public resources.

Perhaps it would be useful to illustrate the nature of this dilemma in terms of economic theory. The basic rationale for intervention in a market economy is that there is some sort of market failure or externality. For some reason there is a divergernce between private and social cost. This difference between private and social cost could provide the rationale for public policy intervention. Figure 6 illustrates this situation. Assume that the cost of producing some imported commodity within the region is given by supply curve S_{∞}, and the import cost is given by I_{∞}. With those costs, none of the good will be produced within the region; all will be imported. Now suppose that there is some sort of market failure such that it is believed

TABLE 3

ANNUAL DIRECT AND INDIRECT CHANGES IN ECONOMIC ACTIVITY DUE TO ETHANOL PLANT CONSTRUCTION
(Average for Three Study Regions)

SECTOR	2.5 mm Gallon Facility			27.5 mm Gallon Facility		
	Sales	Value Added	Employment	Sales	Value Added	Employment
	----thousands---- (1980 dollars)		numbers	----thousands------ (1980 dollars)		number
Agriculture	$ 14	$ 4	*	$ 70	$ 21	2
Mining and Construction	2,538	1,206	32	13,116	6,377	167
Food Manufacturing	37	12	*	187	61	1
Other Manufacturing	3,085	1,330	48	15,907	7,102	259
Transportation Communication & Utilities	327	194	5	1,394	795	20
Trade and Services	1,277	797	42	6,310	4,039	208
TOTAL	$7,278[a] ($4,331)	$3,543[a] ($2,111)	127[a] (71)	$36,984[a] ($22,585)	$18,395[a] ($11,015)	657[a] (368)

[a]Direct effects due to new investment final demand.

SOURCE: This table was taken from Kalter et al., An Analysis of the Economic Impacts from Ethanol Production in Three New York State Regions.

TABLE 4

ANNUAL DIRECT AND INDIRECT CHANGES IN ECONOMIC ACTIVITY DUE TO ETHANOL PLANT OPERATIONS
(Average for Three Study Regions)

SECTOR	2.5 mm Gallon Facility			27.5 mm Gallon Facility		
	Sales	Value Added	Employment	Sales	Value Added	Employment
	----thousands------ (1980 dollars)		numbers	-----thousands----- (1980 dollars)		number
Agriculture	$ 129	$ 56	4	$ 152	$ 65	4
Mining and Construction	319	159	4	1,007	502	13
Food Manufacturing	12,810	2,850	75	13,687	2,917	80
Other Manufacturing	1,716	735	28	3,084	1,332	48
Transportation Communication & Utilities	979	568	13	1,901	1,047	20
Trade and Services	1,690	957	48	2,851	1,885	83
Ethanol	4,206	2,877	44	50,401	4,425	120
TOTAL	$21,850 ($13,512)[a]	$8,203 ($5,115)[a]	216 (103)[a]	$73,083 ($49,371)[a]	$12,173 ($6,811)[a]	368 (183)[a]

[a]Direct effects due to new deliveries to final demand.

SOURCE: This table was taken from Kalter et al., An Analysis of the Economic Impacts from Ethanol Production in Three New York State Regions.

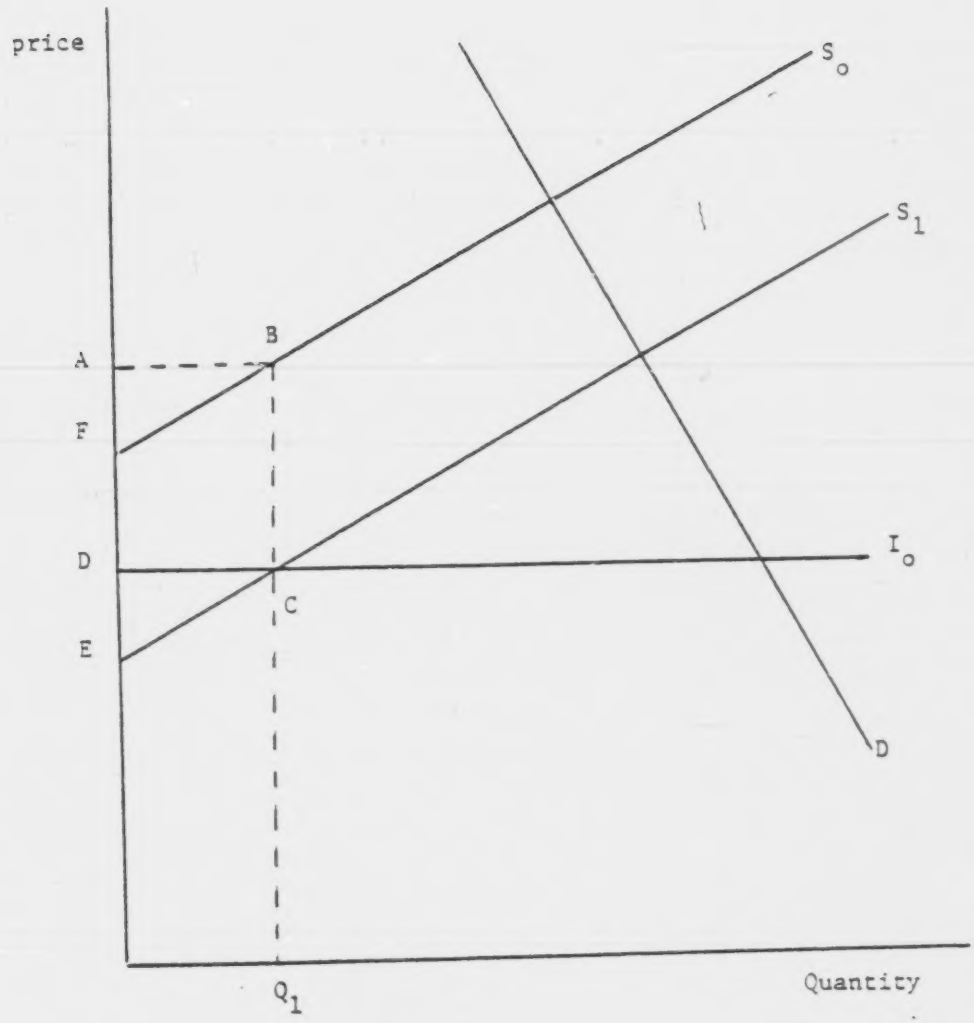


FIGURE 6

ECONOMICS OF REGIONAL COMMODITY SUBSIDIES

advantageous to the region to subsidize production of the good within the region to bring the cost down to supply curve S_1. Now it is "economic" to produce Q_1 of the good within the region and imports are reduced by the same amount. Taxpayers within the region are paying the amount ABCD (=FBCE) to subsidize production. The DCE portion of the subsidy is a transfer (rent) from taxpayers to producers of the good, and the portion FBCD is the net social cost of the subsidy. Those resources have been taken away from taxpayers which causes a reduction in spending and investment elsewhere in the region and nation. Policy makers must believe that the externality has a social cost at least as high as this area to prefer the subsidy. Results regarding employment/income impacts from regional input-output models cannot provide all the information needed to answer the basic policy question. The I-O solutions provide useful information, especially on relative impacts, but the information by itself is inadequate to specify a policy direction.

Mid-west Grain Alcohol Plant

The process of converting grain into alcohol is a well established technology, and the economics of the process have been evaluated in numerous recent studies [The Office of Technology Assessment study is among the best.]. There is no need here to go into the technology or economics as good descriptions are readily available from numerous other sources. Hence, we will move directly into the regional impacts of grain alcohol production.

Regional impacts

The study by Stevenson et al. provides a detailed description of the direct and some of the indirect impacts of Mid-west grain alcohol plants. Table 5 summarizes the employment and earnings generated by several sizes of corn alcohol plants in the Mid-west. Table 6 summarizes the regional direct impacts of alcohol production for several levels of alcohol production. These impacts do not include the indirect or induced impacts of alcohol production from grain in the Mid-west. Stevenson et al. conclude that the greatest impacts of grain alcohol production are in the feedstock production and harvesting. This is the case even for corn which uses only about half the labor that is needed for production and harvest of wheat. Of course, the actual net impacts in this area depend on the opportunity costs for the resources. If demand for grain is high, grain for alcohol likely would come from exports, and the employment impacts in agriculture would be diminished accordingly. If demand and prices for agricultural products is low, regional impacts would depend to some extent on the nature of national farm programs.

Other studies have attempted to estimate the regional direct and indirect impacts of Mid-western grain alcohol production. A Study done by the Iowa Energy Policy Council estimated (the estimation technique was not specified) the direct and indirect

TABLE 5

EMPLOYMENT AND EARNINGS GENERATED BY PRODUCTION OF FUEL-GRADE ALCOHOL FROM CORN

Plant Size (10^6 gal/yr)	Employment (worker-years)				Earnings (10^3 1980 $)			
	Plant Operation & Maintenance	Grain[a] Prod.	Truck[b] Drivers	Total	Plant Operation & Maintenance	Grain[a] Prod.	Truck[b] Drivers	Total
1	7-14	13	0.6	20.6-27.6	51-131	56	10	117-197
2	7-14	26	1.3	34.3-41.3	51-131	112	22	185-265
3	18-20	38	1.9	57.9-59.9	131-187	168	32	331-387
4	18-20	51	2.6	71.6-73.6	131-187	224	44	399-455
5	18-20	64	3.2	85.2-87.2	131-187	280	55	466-522
10	36-41[c]	128	6.3	170.3-175.3	374-554	560	107	1,041-1,221
20	71-83	256	12.7	339.7-351.7	738-1,122	1,120	216	2,074-2,458
50	9i-159	640	31.6	762.6-830.6	1,325-2,976	2,800	537	4,662-6,313

[a]Assumes a full year's employment for a hired farm worker is completed in six or seven months and involves an average of 1250 hours. This is consistent with information reported in Bureau of Labor Statistics, OCCUPATIONAL OUTLOOK HANDBOOK, U.S. Government Printing Office, Washington, D.C., 1979.

[b]Assumes each driver makes three deliveries per day and separate trucks are used for grain and DDG.

[c]Because no data were available on plants in this range, these values are obtained from linear interpolation of numbers of next larger and smaller plants.

SOURCE: Wayne Stevenson et al., Some Employment and Earnings Implications of Regional Biomass Energy Utilization: New England and the Cornbelt States.

TABLE 6

EMPLOYMENT AND EARNINGS FOR ALCOHOL PLANT WORKERS AND TRUCK DRIVERS AT VARIOUS LEVELS OF REGIONAL PRODUCTION

Annual Production (10^6 gal)	Employment (worker-years)			Earnings (10^6 1980 $)		
	Alcohol Plant Workers[a]	Truck Drivers[b]	Total	Alcohol Plant Workers[a]	Truck Drivers[b]	Total
100	182-400	63	245-463	2,700-6,000	1,074	3,774-7,074
200	364-800	126	490-926	5,400-12,000	2,148	7,548-14,148
300	546-1,200	189	735-1,389	8,100-18,000	3,222	11,322-21,222
400	728-1,600	252	980-1,852	10,800-24,000	4,296	15,096-28,296
500	910-2,000	315	1,225-2,315	13,500-30,000	5,370	18,870-35,370
600	1,092-2,400	378	1,470-2,778	16,200-36,000	6,444	22,644-42,444
700	1,274-2,800	441	1,715-3,241	18,900-42,000	7,518	26,418-49,518
800	1,456-3,200	504	1,960-3,704	21,600-48,000	8,592	30,192-56,592
900	1,638-3,600	567	2,205-4,167	24,300-54,000	9,666	33,966-63,666
1,000	1,820-4,000	630	2,450-4,630	27,000-60,000	10,740	37,740-70,740
2,000	3,640-8,000	1,260	4,900-9,260	54,000-120,000	21,480	75,480-141,480
3,000	5,460-12,000	1,890	7,350-13,890	81,000-180,000	32,220	113,220-212,220
4,000	7,280-16,000	2,520	9,800-18,520	108,000-240,000	42,960	150,960-282,960
5,000	9,100-20,000	3,150	12,250-23,150	135,000-300,000	53,700	188,700-353,700

[a]Assumes between 182 and 400 alcohol plant workers with combined earnings of $2.7-$6.0 million per 100 million gallons produced annually.

[b]Assumes 63 truck drivers with combined earnings of $1.074 million per 100 million gallons produced annually.

SOURCE: Wayne Stevenson et al., Some Employment and Earnings Implications of Regional Biomass Energy Utilization: New England and the Cornbelt States.

impacts of alcohol production in Iowa. The results were reported on a per million gallons of ethanol basis. It was estimated that the operating costs would be $1.5 million for each million gallons of production ($1.50/gal.), that there would be $3.36 million in activity generated from that alcohol production spending, which would include increation of 58 new jobs, and that this increased economic activity would result in an increase in state tax revenues of $203,500 annually. In addition, $850,000 previously exported for purchasing petroleum would now be spent in the state resulting in a furthur increase in economic activity of $1.7 million and creation of 46 new jobs and increased state tax receipts of $74,000 yearly. The total increase in state tax receipts of $277,500 would reduce the social cost of the alcohol from $1.5 million to $1,222,500. If alcohol could be consumed with 90 percent of the volumetric efficiency of gasoline, the million gallons of alcohol would displace 900,000 gallons of gasoline, and the net cost to the state would be $1.36 per gallon ($1,222,500/900,000). The argument is that the state could afford to pay $1.50 per gallon of alcohol if the price of gasoline is at least $1.36/gal. If the end use efficiency of ethanol is 95 instead of 90 percent, the breakeven price falls to $1.29/gal.

We will consider these results furthur in light of our earlier review of regional economic analysis. It is important for us to know the assumptions underlying the analysis to properly evaluate the conclusions. First, this analysis implicitly assumes the corn that would be used for alcohol production is new corn that would not detract from corn exports nor from alternative domestic uses. It also assumes that the land that is used to grow the corn for alcohol would be unemployed without the alcohol production; that is, no other crops would be grown on the land nor would the land owner or operator receive any payments from outside the region for not using the land for grain production (like the federal government land retirement or PIK programs).

If input-output analysis or similar technique was used to estimate the impacts, the constant returns to scale assumption also underlies the results. This means that expansion of output could be had at no increase in unit costs. However, in this case, the study also indicates that alcohol production would result in an increase in the price of corn, which violates the original assumption. Most of the research that has been done on the relationship between corn prices and alcohol production has indicated that up to about 2 billion gallons of alcohol, the corn price impacts of alcohol production would be quite small. However, beyond this level, significant corn price increases due to alcohol production are possible. Any corn price increase would increase costs for cattle, swine, and poultry producers as well as prices for consumers. These adverse effects would have to be included in any comprehensive consideration of alcohol policy.

The study methodology also implicitly assumes there are no

better opportunities for use of the investment funds required for the alcohol plants. In other words, no other investments would occur which would generate economic activity in the absence of an alcohol program. Consider an alternative. The state could promote investment in export industries instead of an alcohol industry. In that case, the state (region) would reap the multiplier effects associated with export industries and also still be able to take advantage of the lower cost liquid fuels from petroleum. So the state could have the lower cost energy and also the tax receipts from the export industry.

From a social perspective, one could argue that corn is a "free good" at least to the point that corn prices begin to increase significantly due to increased demand for alcohol. This argument assumes we are likely to continue to have farm programs that stimulate more corn prouduction than can be absorbed in the market at government supported prices. From that perspective, it could be argued that to the extent that market purchases of corn for alcohol production result in a lower cost for the farm subsidy programs, the net cost of the alcohol subsidy is lower than it appears to be on the surface. Although it is difficult to quantify and forecast the magnitudes involved, it does appear that the strongest argument in favor of an alcohol subsidy program is that, if well managed, it could reduce the cost of farm subsidies.

Another study examined the economics of alcohol fuels in Illinois [Rao and Walzer]. That study used a combination of input-output and economic base analysis to produce the employment impacts of alcohol production. Employment was estimated for a range of alcohol market penetration rates within Illinois. The authors concluded that the direct employment in the industry would be small, but that the stimulation in aggregate demand would have a very positive effect on the economy. However, some of the same problems mentioned above with respect to the Iowa study hold as well for the Illinois study.

Potential production

Most studies have indicated that alcohol production growth is limited mainly by economics and availability of grain or other raw materials at competitive prices. If economic conditions were favorable, there seems to be little doubt that production could grow by several hundred thousand gallons per year after a short start-up period. However, as indicated above, after 2-3 billion gallons are reached, corn prices will begin to rise. Also, soil erosion becomes more of a problem with more corn being grown on marginal and more erosive lands.

Wood Fired Power in New England

In forested regions of the country wood has potential as a fuel not only for generation of electric power but also for industrial fuel and as a source of residential heat. Two different studies examined for this paper estimated the employment and earnings impacts of wood use in an electric power

plant in New England. For our purposes here it is useful only to provide a brief summary of the results of these studies.

Regional impacts

Table 7 provides a summary of the direct employment impacts of wood fired electricity generation in New England [Stevenson et al.]. In addition to these estimates of direct employment impacts, Vander Werf did a study of regional employment and income effects of a wood fired electric power plant in New England. He used input-output analysis to produce his regional estimates. Vander Werf used the standard practice of beginning with the national I-O tables and creating a regional table from the national tables. He concluded that each 50 MW wood power plant would result in the creation of 189 direct jobs, a number that agrees well with the Stevenson figures from Table 7. In addition, he calculated that 96 indirect jobs would be created consisting of 36 in retail trade, 10 in wholesale trade, and 40 in the medical and health professions. In addition, 244 new construction jobs would be created during the construction period.

There has been no study to this author's knowledge which examines the regional impacts of wood fired electric power using macro-economic models coupled with input-output analysis. Hence, these results suffer from the same problems mentioned several times before, in that they provide only a partial picture of the economic impacts on the region.

TABLE 7

EMPLOYMENT RELATED TO OPERATION OF WOOD-FIRED ELECTRIC GENERATING PLANT

Plant Size and Load Factor	Annual Output (10^3 kWh)	Wood Requirements[a] (50% moisture)		Employment (workers per year)				
		Tons/day	Tons/yr	Boiler[b] Op. & M.	Transp.[c]	Wood Chipping[b] Crews	Wood Chipping[b] Workers	Total
10 MW								
30%	26,280	134	48,749	16-25	3	1.02	9	28-37
50%	43,800	223	81,249	16-25	5	1.69	15	36-45
70%	61,320	312	113,749	16-25	8	2.37	21	45-54
100%	87,600	445	162,498	16-25	11	3.39	30	57-66
25 MW								
30%	65,700	334	121,873	30-40	8	2.54	23	61-71
50%	109,500	557	203,123	30-40	14	4.23	38	82-92
70%	153,300	779	284,372	30-40	19	5.92	53	102-112
100%	219,000	1,113	406,245	30-40	27	8.46	76	133-143
50 MW								
30%	131,400	668	243,747	40-60	16	5.08	46	102-122
50%	219,000	1,113	406,245	40-60	27	8.46	76	143-163
70%	306,600	1,558	568,743	40-60	38	11.85	107	185-205
100%	438,000	2,226	812,490	40-60	54	16.93	152	246-266

[a]Assumes the 1 kWh can be produced by the effective application of 3413 Btu, that boiler efficiency is 65 percent, generator efficiency is 35 percent, yielding power plant efficiency of (0.65)(0.35) = 23 percent. Thus, 50 percent moisture content wood which would produce about 4000 Btu per pound will yield an effective thermal output of 920 Btu per pound or 1,840,000 Btu per ton, so 1.855 tons of 50 percent moisture content wood are required per 1000 kWh produced.

[b]Based on 24-hour staffing 365 days per year.

[c]Assumes an average 60 tons per driver per day (i.e., three 22-ton trips minus 10 percent loss due to maintenance time). Annually this results in 15,000 tons per driver assuming 5-day weeks and 50-week years or 10-hours per day for 40 weeks per year. This is consistent with findings for an average 70- to 80- mile round trip hauling mill residues 50 weeks per year or harvested wood chips 40 weeks per year.

[d]Assumes whole-tree harvesting on selectively cut land yielding 240 tons per 9-worker crew per day (includes supervisory and clerical workers). Assuming 5-day weeks for 40 weeks per year this yields 48,000 tons per crew per year.

SOURCE: Wayne Stevenson et al., Some Employment and Earnings Implications of Regional Biomass Energy Utilization: New England and the Cornbelt States.

SUMMARY

This section contains a summary of the most important points from this study directly relevant to the broader OTA analysis of oil displacement options. It is not a summary of the entire paper, but contains the major conclusions from each section. The major conclusions are as follows:

1. The national policy environment in place at or immediately after an oil supply disruption will play a large role in determining the extent to which any of the oil displacement options will be implemented. Without adequate economic incentives, none of the oil displacement options will be pursued. Also, any policy that is established must be viewed by the public as being fair.

2. It would be advantageous to develop a response policy set now so that the policy can be developed with careful thought and analysis and be ready to implement when a disruption in oil supply takes place.

3. Input-output techniques are commonly used to estimate employment and earnings impacts of energy alternatives. Several studies have been done estimating the impacts of solar energy development strategies. The results from these are indicative of impacts that might occur from other similar investments.

4. There is little doubt that significant direct employment impacts would result from investments in renewable energy technologies. However, results from studies of direct or direct plus indirect impacts alone are not an adequate basis for making policy choices at national or regional levels.

5. Policy comparisons must be made by examining the total costs and benefits to a region or nation rather than just the jobs created. To use a single factor (labor) input as a guide for policy conclusions omits other components of social costs and benefits. Increased employment may be indicative of declining labor productivity, which in the long run, means declining real wages for labor.

6. To consider all the factors relevant to regional or national energy investment policy requires a computable general equilibrium model or set of linked models. Otherwise, there is the likelihood that the changes in exogeneous demand used for the I-O calculations will not include all the macro-economic effects.

7. Several studies have been done with linked I-O and macro-economic models. The fundamental conclusion reached by these studies is that the national economic impacts of solar energy development depend on its cost relative to that of the alternatives. If the solar cost is lower, positive economic benefits would be received; if the solar costs are higher, GNP growth, income, and employment would be lower under the solar option than with the conventional sources. These same

conclusions would hold for other renewable energy sources.

8. It appears likely that the differential regional impacts of rising energy prices have been exagerated. Three-fourths of the nation's jobs are in activities not very vulnerable to rising energy prices. It is likely that the "disruptive" impacts on energy importing regions will be much less severe than the large-scale and rapid movement of the textile industry from the North to the South after World War II [Miernyk].

9. Even when a lot of information is available on local or regional impacts of possible energy investments (such as from the New York state cheese whey study), the decision on whether or not or the extent to which to subsidize local investments usually must be based on a political judgement of social benefits and costs.

10. The principle of comparative advantage applies to a region just as it does to a nation. Generally, a nation will be better off (higher incomes and growth) producing those goods for which it has a comparative advantage rather than following a policy of using subsidies to achieve import substitution objectives. In determinng regional policy, it is very important to consider the opportunity costs of resources that would be used to subsidize any specific industry.

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